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For

An Apparatus To Use A Refrigerator in Mobile Computing Device

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An Apparatus To Use A Refrigerator in Mobile Computing Device

Field of Invention

[0001] The field of invention relates generally to heat management and more particularly to heat management using a refrigerator in a mobile computing device.

Background

[0002] Heat management can be critical in many applications. Excessive heat can cause damage to or degrade the performance of mechanical, chemical, electric, and other types of devices. Heat management becomes more critical as technology advances and newer devices continue to become smaller and more complex, and as a result run at higher power levels and/or power densities.

[0003] Modern electronic circuits, because of their high density and small size, often generate a substantial amount of heat. Complex integrated circuits (ICs), especially microprocessors, generate so much heat that they are often unable to operate without some sort of cooling system. Further, even if an IC is able to operate, excess heat can degrade an IC's performance and can adversely affect its reliability over time. Inadequate cooling can cause problems in central processing units (CPUs) used in personal computers (PCs), which can result in system crashes, lockups, surprise reboots, and other errors. The risk of such problems can become especially acute in the tight confines found inside mobile computers and other portable computing and electronic devices.

[0004] Prior methods for dealing with such cooling problems have included using heat sinks, fans, and combinations of heat sinks and fans attached to ICs and other circuitry in order to cool them. However, in many applications, including mobile and handheld computers, computers with powerful processors, and other devices that are small or have limited space, these methods may provide inadequate cooling.

Brief Description of the Drawings

[0005] **Figure 1** presents an illustration of a refrigerator for thermal management of a heat generating unit within a mobile computing device, in accordance with one embodiment.

[0006] **Figure 2** presents an illustration of a refrigerator for thermal management of a heat generating unit within a mobile computing device, in accordance with an alternative embodiment.

[0007] **Figure 3** presents an illustration of a refrigerator for thermal management of a heat generating unit within a mobile computing device, in accordance with an alternative embodiment.

[0008] **Figure 4** presents a flow diagram describing a process of using a refrigerator for thermal management of a heat generating unit within a mobile computing device, in accordance with one embodiment.

Detailed Description

[0009] An apparatus to use a refrigerator in a mobile computing device is described. In one embodiment, the refrigerator includes a cold reservoir to absorb heat generated by a heat generating unit of the mobile device. A heat exchanger is used to dissipate heat of a hot reservoir of the refrigerator. In an alternative embodiment, the apparatus includes a working fluid loop, with fluid of the loop in thermal contact with the heat generating device, and the cold reservoir of the refrigerator to absorb heat from the fluid.

[0010] In the following description, numerous specific details are set forth. However, it is understood that embodiments may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the understanding of this description.

[0011] Reference throughout this specification to "one embodiment" or "an embodiment" indicate that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In addition, as described herein, a trusted platform, components, units, or subunits thereof, are interchangeably referenced as a protected or secured.

[0012] **Figure 1** illustrates one embodiment of a refrigerator for thermal management of a heat generating unit within a mobile computing device. As illustrated, the refrigerator 102 includes a cold reservoir 104 and a hot reservoir 106. The cold reservoir absorbs heat generated by a heat generating component 108

within the computer system. The heat generating component may include a processor, a chipset, a graphics controller, a memory controller, and other alternative heat generating components.

[0013] In one embodiment, the cold reservoir 104 is in thermal contact with the heat generating component 108. In one embodiment, as illustrated in **Figure 1**, heat from the heat generating unit is transferred to the cold reservoir 104 of the refrigerator 102. The heat is then transferred to the hot reservoir 106, where the heat dissipates. The refrigerator used with the techniques, as described herein, may be either of a vapor compression, a thermoelectric, thermoionic, a magnetic, a thermo acoustic, an absorption, or adsorption. Other types of a refrigerators may also be used.

[0014] In an alternative embodiment, illustrated in **Figure 2**, a heat exchanger 112 is used to dissipate heat from the hot reservoir 106 of the refrigerator 102. In one embodiment, a heat exchanger fan 110 may be provided to supply air across the heat exchanger 112.

[0015] In an alternative embodiment illustrated in **Figure 3**, a working fluid loop 114 within the computing device 100 is used in conjunction with the refrigerator 102 to absorb heat of the component 108. As illustrated, the fluid of the loop 114 is pumped across the component 108, to absorb heat from the component. In one embodiment, working fluid loop 114 passes across or through a cold plate thermally attached to the component 108 to absorb and transfer heat from the cold plate. In one embodiment, a pump 118 is used to move the fluid thru the working fluid loop 114. In alternative embodiment, other ways of moving the fluid may be used.

[0016] Thereafter, the working fluid and/or vapor are passed through a heat exchanger 116 to dissipate heat. In one embodiment, the heat exchanger 116 is a

fluid to air heat exchanger, wherein the fluid passes through a thermally conductive tube that may include fins attached to the tube to dissipate the heat from the working fluid and/or the vapor. A fan may be used to blow across the channels to dissipate the heat.

[0017] Thereafter, the working fluid of the loop 114 is passed across the cold reservoir 104 of the refrigerator 102, which absorbs additional heat from the working fluid. The working fluid of the loop 114 returns across the heat generating component 108, as described above. As illustrated in **Figure 3**, the refrigerator 102 is located remotely from the heat generating component 108, in accordance with one embodiment. Alternatively, the refrigerator 102 may be located outside the mobile computing system in a docking station, or possibly as an external module.

[0018] In one embodiment, the refrigerator 102 can be turned on or off based on a predetermined event, such as a temperature of the heat generating component 108, an internal ambient temperature of the computing device 100, a level of power provided to the component 108, whether the computing device 100 is receiving power from a battery source or power from an AC outlet, or other events. The flow diagram of **Figure 4**, describes an example embodiment of the refrigerator 102 that is able to be turned on or off based on a temperature of the component 108.

[0019] In process 402, the refrigerator 102, a pump 116 of the fluid loop 114, and the heat exchanger fan 110 are off. In process 404, in response to the temperature of component 108 reaching a predetermined level a first time, the pump 116 is powered on, and the refrigerator and heat exchanger fan remain off. In process 406, in response to the temperature of component 108 reaching a predetermined level a second time, or reaching a separate predetermined level a first time, the heat exchanger fan is powered on, and the refrigerator remains off. In process 408, in

response to the temperature of component 108 reaching a predetermined level a third time, or reaching a separate predetermined level a first time, the refrigerator is powered on. In alternative embodiments, the units, and the sequence of the units being powered on may vary. Also the predetermined events that trigger the units to be powered on, may vary.

[0020] In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. For example, in one embodiment, the foregoing thermal management technique could be provided in a mobile computing device having a wireless antena to communicate wirelessly with separate devices. In another example, the above described thermal management technique could be applied to desktop computer device. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.